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Herbage Production Under Ponderosa Pine Killed by the Mountain Pine Beetle in Colorado

by

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Herbage growth increased steadily over 4 years, beginning the year after beetle attack. Yields of forbs, sedges, and grasses contributed most to gains of between a quarter and a half ton per acre of dry herbage. Yields of herbage were not increased in the shade of saplings where overstory trees were killed by beetles. Rapid herbage growth and the mulch provided by fallen dead pine needles appeared to help prevent soil erosion.

Keywords: Herbage yield, mountain pine beetles, ponderosa pine mortality

Land managers preparing to deal with mountain pine beetle (*Dendroctonus ponderosae* Hopkins) often lack needed quantitative information on the effects of the outbreaks on values other than those for timber. Not all of the consequences of an outbreak are bad. For example, forage increases under beetle-killed trees benefit cattle and big game production (Leuschner and Maine 1980) and watershed protection.

The amount of herbage under ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) is known to vary inversely with the density of trees (Pearson and Marsh 1935, Pase 1958, Clary and Ffolliott 1966, Agee and Biswell 1970, Severson and Boldt 1977). Logging and fires frequently stimulate increases in the growth of understory vegetation; therefore, it is logical that stand thinning resulting from bark beetle-caused tree mortality would similarly stimulate increased herbage production.

This study was designed to determine the amount of herbage production under ungrazed ponderosa pine stands which have been largely destroyed by the mountain pine beetle, how soon herbage growth responds after tree mortality, and how long any increase persists.

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The data were collected from two widely separated areas on or near the Roosevelt National Forest, in north central Colorado.

Methods

Two essentially uninfested areas of pure ponderosa pine were selected for study during August of the year of initial attacks by mountain pine beetles. Both areas harbored huge beetle populations, and trees within the study areas were considered likely candidates for subsequent beetle attacks.

One study area was at Lory State Park, 7 miles west of Fort Collins, at an elevation of 6,820 feet. Average annual precipitation, estimated from nearby reporting stations, is about 17 inches. Soil is derived from the Wetmore-Boyle-Moen complex, essentially acidic (pH 6.1-7.3), and "Consists of well-drained deep, gently sloping to steep soils of mountain sides. The surface layer is about 8 inches of loam. The subsoils are about 33 inches of clay loam. Below this is about 15 inches of sandy loam clay overlying weathered granite." ² Rock outcrops are numerous. Actual soil conditions were somewhat less abundant than described.

²USDA, Soil Conservation Service soil interpretation of August 8, 1975, Larimer County, Colorado.

Data from Lory were taken from four rectangular plots totaling 0.77 acres, along a flat, somewhat narrow, ridge. Two plots had slightly western, and two had slightly eastern exposures. The plots were within an area of about 2 acres and were kept small in order to confine sampling to relatively homogenous stand conditions which appeared at equal risk of beetle attacks. They also provided a measure of data variability between plots near each other.

The second study area, called Log Cabin, is about 24 miles northwest of Fort Collins, at an elevation of 7,700 feet. Average annual precipitation is estimated to be about 18-20 inches. Soils are similar to those at Lory State Park, but terrain is much less steep.

Data from the Log Cabin site were taken from two, rectangular one-third acre plots within an area of 3 acres.

Vegetation was sampled by clipping all plants at ground level from fifty, 2-square-foot rectangles which were equally spaced along 10 sample lines spaced equidistant within each of the 6 plots. The location of the clip units was varied a little each year to preclude repeated sampling of the same spots. Plots were sampled annually, over 4 years, during late August or early September.

Vegetation was classified as either shrub, forb, sedge, or grass. At each clip plot, the vegetation was placed in paper bags, by classification, and dried that evening for 24 hours at 212°F. Dried vegetation was weighed in grams and statistical calculations made in these units. Data were then converted to pounds per acre.

The trees at Lory State Park were being attacked by beetles during initial sampling in late August 1974. At Log Cabin, trees were undergoing initial beetle attacks in 1975, but sampling was delayed 1 year while fences were erected to exclude grazing by cattle and horses. Grazing had been excluded within Lory State Park.

The diameters of all trees 4.5 feet and taller were measured at breast height to determine basal area of live trees before and after mountain pine beetle attacks.

The area within the drip line of all live trees was measured, and the total area thus determined was considered the original crown cover. Crown cover of overtopped trees was not added unless portions of such crowns could contribute drip line areas of their own. Thus, in some cases, as overstory trees were killed, crown cover was not reduced if small live trees were growing under them. The percent of live crown cover, in relation to the original live crown cover, was estimated each year as vegetation samples were collected.

Results and Discussion

Herbage production under ponderosa pines killed by mountain pine beetles increased the year after beetle attack and accelerated noticeably as needles fell from the dead trees by the second growing season (fig. 1). Yield increased from a few pounds to between one-quarter and almost one-half ton in 3 years (table 1). Forbs, sedges, and grasses contributed to the gain. Shrub yields were too erratic to infer a trend. This could be partly a result of the destructive nature of sampling.

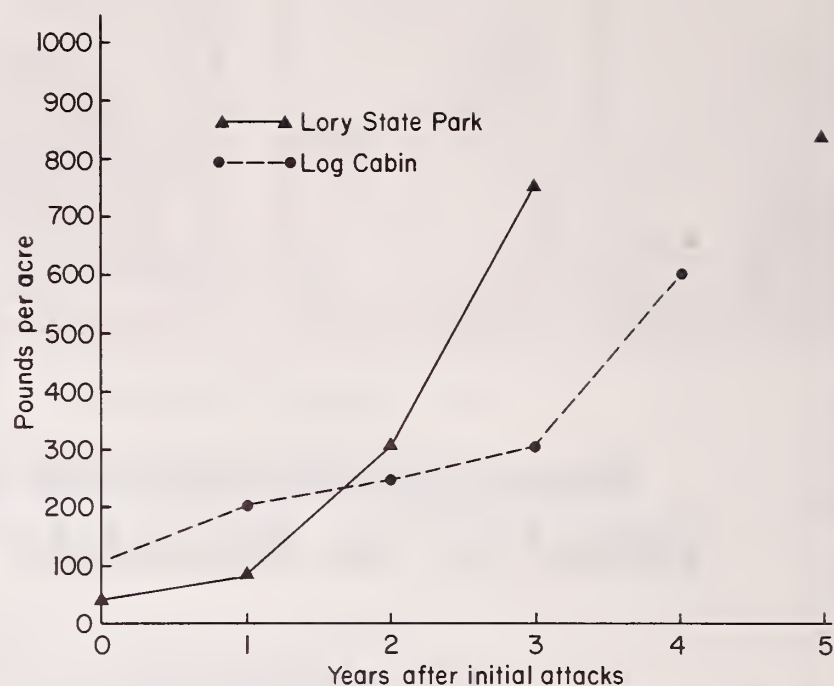


Figure 1.—Total herbage yield in pounds per acre after initial mountain pine beetle attack.

Where beetles killed many trees over 2 years, yields from forbs, sedges, and grasses increased substantially the third summer. Where tree mortality was more gradual, herbage increase was more gradual, as shown for the Log Cabin plots where no additional crown kill occurred the third year after beetle attack (table 2). Where beetles killed no trees in stands near the study sites, herbage yield appeared to vary little, if any, during the sampling period.

It was evident that regardless of the amount of the overstory crowns that were killed, small, suppressed trees that were not attacked by mountain pine beetles, provided sufficient shade, possibly in combination with some other influences, to prevent herbage encroachment. This interrelationship is discussed by Moir (1966), who concluded that shade and poor soil nitrogen acted together to cause decline in herbage production. This phenomenon would be of considerable importance where ponderosa pines have developed as two-storied stands. The small understory trees would greatly hinder herbage production.

The residual stand, under which the herbage reached maximum yields, consisted of 153 trees per acre at Lory State Park. Mean diameter of these trees was 4.8 inches d.b.h. The residual, live stand at Log Cabin contained 439 trees per acre, with a mean diameter of 3.7 inches d.b.h. For the most part, these residual, green trees tended to grow in clusters. The original stands were 420 and 532 trees per acre, respectively, with mean tree diameters of 7.5 and 5.9 inches d.b.h. for trees 4.5 feet and taller.

The yield of forbs at Lory State Park was greatly influenced by a single species of thistle (*Carduus nutans* L.) in 1979. This plant accounted for almost all of the 285 pounds of forbs that year. The spread of thistle from 1977 to 1979 was so great that any future samples from plots 2 and 4 would be made up of that plant only.

During the sampling period, no noticeable increases in erosion resulted from beetle-caused tree mortality, even though two heavy rainstorms occurred in late July—one in 1976 that produced 5-8 inches in 5 hours,³ and one in 1977 when approximately 5 inches fell in a 24-hour period.⁴ Both storms caused gullying, but erosion under beetle-killed trees appeared no different than under stands of healthy trees. However, where litter and duff layers are thin over more erodible soils, or on steeper slopes, beetle attacks resulting in tree mortality may facilitate soil erosion.

The herbage increases under beetle killed ponderosa pine would not always be of benefit to grazing animals in the forest. In addition to the unpalatable thistle mentioned earlier, cheatgrass (*Bromus tectorum* L.) was also found in increasing amounts on some plots. Unless this plant is consumed when green, it soon becomes unpalatable.

The increased quantities of fine, herbaceous fuels will contribute to the potential for faster spreading, and possibly more intense, wildfires.

³McCain, Jerald F., Lee R. Hoxit, Robert A. Maddox, Charles F. Chappell, and Fernando Caracena 1979. Part A. Meteorology and Hydrology in Big Thompson River and Cache la Poudre River Basins, in Storm and Flood of July 31-August 1, 1976, in Big Thompson River and Cache la Poudre River Basins, Larimer and Weld Counties, Colorado. U.S. Geological Survey Profession Paper 1115, 152 p.

⁴Climatological Data, July 1977, Vol. 82(7).

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Table 1.—Herbage yield, in pounds per acre, under ponderosa pine killed by mountain pine beetles, Lory State Park. Initial beetle attacks in 1974

Year	Infestation age	Basal area live trees	Crown alive	Shrubs	Forbs	Sedges	Grasses	Totals	Precipitation ¹
	years	square feet	percent	$\bar{X} \pm SE$					inches
1974	0	119	97	12 ± 7.1	1.9 ± 0.35	27 ± 2.4	2.3 ± 0.84	43 ± 2.5	5.04
1975	1	—	65	4.4 ± 2.4	19 ± 5.1	47 ± 3.9	9.7 ± 2.2	80 ± 2.6	8.31
1976	2	—	17	3.2 ± 3.5	63 ± 10	160 ± 13	16 ± 12	312 ± 7.6	7.31
1977	3	22	12	4.0 ± 1.7	101 ± 14	457 ± 38	182 ± 28	744 ± 24	9.04
1978	4	22	12	(²)	(²)	(²)	(²)	(²)	8.59
1979	5	22	12	2.4 ± 2.1	285 ± 39	524 ± 40	91 ± 22	902 ± 26	10.11

¹Mean for Estes Park, Fort Collins, and Redfeather Lakes for May, June, July, and August.

²Data not collected.

Table 2.—Herbage yield, in pounds per acre, under ponderosa pine killed by mountain pine beetles, Log Cabin. Initial beetle attacks in 1975

Year	Infestation age	Basal area live trees	Crown alive	Shrubs	Forbs	Sedges	Grasses	Totals	Precipitation ¹
	years	square feet	percent	$\bar{X} \pm SE$					inches
1975	0	91	100	(²)	(²)	(²)	(²)	(²)	
1976	1	—	44	110 ± 63	55 ± 12	4.9 ± 2.7	31 ± 5.2	201 ± 34	5.74
1977	2	—	44	83 ± 47	115 ± 25	20 ± 12	79 ± 17	297 ± 14	11.54
1978	3	25	19	15 ± 6.9	159 ± 53	6.4 ± 3.0	133 ± 29	313 ± 29	8.46
1979	4	25	19	97 ± 71	258 ± 38	64 ± 29	177 ± 34	596 ± 23	9.14

¹Redfeather Lakes, mean for May, June, July, and August.

²Data not collected.



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